INTRODUCTORY LECTURE

DELIVERED AT THE

OPENING OF THE CLASS OF

NATURAL PHILOSOPHY,

IN

MARISCHAL COLLEGE, ABERDEEN.

BY

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PREFACE.

This Lecture is printed, not because the Author supposes it to possess any literary merit or originality; but simply, because several respected individuals, who were present at its delivery, have suggested that it might be useful to diffuse more widely, among the Students and those interested in them, the views and sentiments therein expressed.

INTRODUCTORY LECTURE.

GENTLEMEN,—My appearance here will remind you that the voice of that accomplished instructor, who so long presided over this class, and whose presence animated these halls, is now silent. Although I had not the privilege of knowing his worth from personal intimacy, I have learned enough from his friends and grateful students, both here and in many parts of the country, to assure me, that the great extent and variety of his attainments, and his eminent talents as a teacher, not only have conferred permanent lustre on this University, but will insure him a lasting and venerated place in your recollections. While we cherish his memory, and endeavour to imitate his virtues, it is the duty of us all —Teachers and Students—to think how soon we may come to the end of our labours, and how suddenly we may be called on, like him, to render a final account of all our studies and all our talents.

It is not my intention at present to discuss in detail the nature and objects of Natural Philosophy. I think it more advisable for me to state, at this our first meeting, some general views and principles, which I shall consider it my duty to keep constantly before me in teaching this class.

I. I shall endeavour to explain to you the important relation which Mathematics bears to Natural Philosophy.

The study of Mathematics, by exercising and cultivating the reasoning faculties, prepares the mind for engaging in any pursuit requiring close attention and consecutive

thought; but, besides this, it is specially necessary as a preparative for the study of Mechanical Philosophy, because Mathematics is the great instrument by which such Science is constructed.

Pure Mathematics is not an inductive but an abstract Science; it deals with such ideas as *space*, *magnitude*, *number*, and it may be defined to be, the investigation of the relations of these ideas by means of general symbols. As the objects it connects and combines are not furnished by the senses, and as the axioms and first principles regarding them are capable of distinct and precise enunciation, the mind, in such a field, is at liberty to follow out a concatenated process of deduction, undisturbed by imperfections of the senses, by varieties in the meanings of words, or by the variable testimony of experience. The habits formed in this region of pure intellect give to the mind a power of sustained attention, a confidence in its own efforts, and a perception of the nature and strength of evidence, which are not to be obtained from the study of mixed sciences. And it was for such purposes that *Mathematics* was sedulously cultivated by the Greeks, the term itself indicating this its character of *disciplinal* studies. It is fortunately not necessary for me to say much in favour of the position, that Mathematics is admirably and exclusively fitted for this purpose of discipline. Such a use is generally admitted; indeed, this is its highest recommendation and most valuable quality, and is that which gives the subject its place in a system of intellectual culture. But Mathematics stands in a peculiarly favourable position for any argument as to *utility*, because the only way in which a person can acquire such a knowledge of its doctrines as to feel any confidence or ease in their application, is to study the subject as a strict science; so that, whether we had to educate an engineer or a lawyer, we would teach the subject in its strictly philosophical character. And thus, the place that

Mathematics ought to hold in the courses of education of our higher Schools and Colleges is easily determined. It ought to go hand-in-hand with those studies which cultivate the taste, and memory, and imagination, if it be allowed that the faculties of reasoning have an equal claim to nurture and attention. By introducing an amount of Mathematical instruction equal to its value, we accustom the mind to arrange, and reason upon, its ideas,—to trace out with accuracy the axioms or sources of its knowledge,—and to exercise that habit of connected thinking, "which," says Dugald Stewart, "in all pursuits of life, whether speculative or active, is one of the most valuable endowments we possess."

You will hear occasionally objections which may tend to discourage you in the pursuit of this noble study. It is a severe, but I suspect a true observation of Montucla, made in his *Histoire des Mathématiques,* upon those who treat the study of Mathematics with ridicule or contempt, that such clamour proceeds only from strangers to the science, from persons of superficial minds, who condemn what they do not understand.* You ought to be made aware, that the objections turn chiefly on the *exclusive* study of Mathematics. Now, we argue for no such exclusive culture of any faculty, or set of faculties, as would produce a distorted intellect. The exclusive study of Mathematics *may* have such an effect, just as an exclusive devotion to Languages, or to Metaphysics, or to Poetry. We allow at once that the subject is abstract, and that it deals not with the objects of ordinary life. But these abstract studies are

* "Pour apprécier au juste ces plaisenteries ou ces clameurs, il suffit de remarquer qu'elles ne partent que de gens tout-a-fait étrangers en géométrie et en physique, ou de quelques esprits superficiels, à qui l'impuissance de suivre la même marche fait prendre le parti beaucoup plus facile de blâmer ce qu'ils n'entendent pas."—*Montucla. Histoire,* I. 168.

so intimately mixed up with others in this University, that there is no danger of your perceptions of moral reasoning being impaired, or of your minds being estranged from the common processes of life. Here you have many studies so combined as to produce a wholesome and equal training. And, when you diverge from College to various professions, if you take along with you any solid Mathematical acquisitions, you will not lose your reward. The Lawyer and the Divine will have acquired a view of that model of perfect demonstration, to which, in their more mixed researches, they will do well to endeavour to approximate; those who are to follow professions, the methods of which are based on inductive science—such as the Physician and the Engineer—will be possessed of general views and doctrines which give them a position superior to those who deal with such matters empirically, and not scientifically—who trust to the reasonings of others, and, consequently, are always at their mercy; the general scholar will be furnished with principles which qualify him to take an intelligent interest in the onward progress of mechanical improvement; and all must have acquired, in different degrees, that love of truth, and expansion of mind, which are so well calculated to elevate them in the scale of intellectual beings.

But the connection of Mathematics with Natural Philosophy—especially with the mature branches of Mechanics, Astronomy, and Optics—is still closer and more important. As these Sciences have to deal with such notions as *time, motion, velocity*, &c., they require the constant aid and attendance of Mathematics in the work of establishing their great generalizations, in the varied processes of deduction, and in the very expression and statement of relations. It is impossible to conduct reasoning on such subjects without using that language in which our knowledge of abstract quantity is embodied; and it is, in a great measure, the

strict and precise reasoning consequent on the use of such language that gives to our modern Mechanical Philosophy its high value, and its unquestioned accuracy. It is not easy to prove this to those who are unacquainted with the subject; and those who accurately understand it need no arguments to satisfy them of the invariable connection of these sciences, or of the fact that the *one* has been constantly dependant on the *other*, during all the stages of their progress. For example, let us refer to that portion of the system of the world, developed by Newton, which proves that the moon and planets revolve in orbits round their primaries, under the action of a central force, which is inversely as the square of the distance,—and that this force, as exerted by the earth on the moon, is identical with the force of terrestrial gravity. As a trial of what was at first conjectural, Newton had merely to take the quantity which the moon had, in a given time, deflected from the tangent to its orbit, and, by an obvious arithmetical calculation, try whether this quantity was, to the distance fallen through by a body near the earth's surface, in the same time, inversely as the squares of the distances from the earth's centre. His conjecture was verified, not on the first, but on the second trial. But Newton knew better the rigour of inductive philosophy than to consider the establishment of this truth as all that was required; in fact, he had previously set himself to the general mechanical problem of finding, from purely dynamical considerations, the path which a body must travel over when projected by a given force, and acted on by a central. To this enterprise he had to bring not only extensive mathematical *knowledge*, but powers of *discovery* sufficient entirely to create a new branch of Mathematics, called for by his researches. And he succeeded in showing—by the happiest combination of the properties of the conic sections established by the ancient Geometers, with his own newly-discovered method of limits and limiting ratios—

that a body, projected in a straight line, and subjected to the action of a central force, *must* revolve in one of the conic sections, if that central force vary inversely as the square of the distance. Let me draw a conclusion on this point, in the eloquent words of Professor Sedgwick:—"To follow in this tract, first trodden by the immortal Newton, to study this language of pure unmixed truth, is to be regarded not only as your duty, but your high privilege. It is no servile task, no ungenerous labour. The laws by which God has thought good to govern the Universe are surely objects of lofty contemplation, and the study of that symbolical language, by which alone these laws can be fully deciphered, is well deserving of your noblest efforts."*

The doctrines of Natural Philosophy do not ultimately rest on the same kind of evidence as those of Mathematics, and we think it the duty of a teacher of science to distinguish carefully and constantly between *inductive* principles derived from observation, and those abstract doctrines which are *deduced* from the axioms of pure science. It is of the utmost consequence that these should not be confused in the student's mind. Natural Philosophy is built up of combinations of both kinds; but, when a mechanical doctrine has been established, our after reasonings may be conducted mathematically, and they carry along with them that evidence which no special experiments can furnish. Thus, in the above case of Newton's discovery, there are involved inductive principles derived from experience, such as these, that "terrestrial gravity is a uniform force," and the well known "laws of motion," previously arrived at by Galileo and others, but generalized by himself. Such truths are sometimes styled *physical axioms;* and, although axioms of

* Sedgwick. "Discourse on the Studies of the University of Cambridge." Page 11.

pure science are obtained in a very different way, both may become the foundation of Mathematical reasoning.

This mixed character of Natural Philosophy suggests the proper mode of teaching its doctrines. The scientific method requires the student to bring with him so much acquaintance with Mathematics as will qualify him to follow, to a certain extent, those processes of reasoning by which the laws have been investigated; thus fitting him to secure that perfect hold and comprehension of mechanical laws which will enable him to use and apply them with confidence, and also to acquire such an insight into the incontestible evidence on which they are founded, as will produce an unwavering conviction of their truth and certainty. But this method by no means excludes the use of experiment, for exhibiting the fundamental facts of each induction, for furnishing sensible objects which can be contemplated and remembered, or for exemplifying practical applications.

For the accommodation of those who have not undergone this previous training in abstract science, and who study more for recreation than discipline, another mode has been adopted. This consists of discarding the rigid reasonings of the science, taking most of the great laws of nature for granted as established beyond doubt, illustrating some of their results by individual experiments, and explaining their more obvious applications. Such *illustrations* of Mechanical Philosophy may convey a general notion of some of the results of science; but, as the loose and popular reasoning necessary to be adopted could never have reared any stable superstructure, so must it fail in imparting any solid belief, or any power of useful application. The first method is the only one entitled to be followed in a course of Academical instruction, because it is the only one fitted to administer to that culture and discipline of the mind, which it is the great object of a College education to secure. These sciences are introduced as a part of your curriculum, mainly

as conducive to the training of the mind, to the strengthening of its faculties by exercise—as Horace recommends—

"Mentes asperioribus
Formandæ studiis."

But we are willing to allow that interesting information, innocent and rational amusement, and even some expansion of mind may be derived from a course of popular illustrations of Natural Philosophy. And, although such teaching can give no conception of the solid foundation on which the laws of Mechanical Philosophy are founded, something like confidence in them may be acquired by the contemplation of verified results, and fulfilled predictions; just as the occurrence of eclipses exactly at the time foretold, or of the celestial phenomena detailed in the nautical almanac, may lead unscientific men to a confidence in the truth of the great laws which give rise to these striking results. Besides, there are various branches of natural science which have not attained to such precision as to be susceptible of mathematical treatment, such as Chemistry, Geology, and many portions of Electricity. But, in the case of those sciences which *have* attained such perfection and generalization, we really do not teach the subject if we exclude their Mathematics; and, were we to attempt so to give the form without the substance, we should be throwing away the very qualities which give them a place among those exercises, the main object of which is to form *habits of thought*. From the time of Archimedes to the present day, no royal road to learning or science has been discovered. Here is the language of one well qualified to pronounce an opinion*: —"Admission to its sanctuary, and to the privileges and feelings of a votary, is only to be gained by one means,—

* Sir J. F. W. Herschel. Treatise on Astronomy. Art. 7.—The Italics are in the original.

a sound and sufficient knowledge of Mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in this, or any other of the higher departments of science, as can entitle him to form an independent opinion on any subject of discussion within their range."

II. It appears proper next to explain the view which we shall endeavour to keep before us, as to the relation of science to the Arts, or to practical purposes. This is the more necessary, as a good deal of confusion of thought and of misapprehension prevails on the subject. Some, apparently led away by the use of the word *Mechanical*, in the arts or in common language, seem to suppose that the study of Mechanical Philosophy is an initiation into the processes of the Engineer, the Builder, and the Machine-maker — a learning the secret rules of art; while, on the other hand, there are those who imagine that this science is all theory, something quite visionary and useless, furnishing nothing that is applicable in practical operations.

Now, although there is a connection, there is a wide difference, between Science and Art. Philosophy searches for truth, for general laws; and, when directed to the material world, it seeks for the causes of that round of changes going on in the visible universe. "When Art has brought forth her product, her task is finished. Science is constantly led by one step of her path to another—each principle which she obtains impelling her to go onwards to others more general, more profound, more simple. Art puts elements together without enquiring *why* they coalesce. Science analyzes the compound; and at every such step strives not only to perform, but to understand the analysis. Art advances in proportion as she is able to bring forth products more multiplied, more complex, more various; but Science,

straining her eyes to penetrate more and more deeply into the nature of things, reckons *her* success in proportion as she sees, in all the phenomena, however multiplied, complex, and varied, the results of one or two simple and general laws. Art may lay down rules; but it is not her business to find reasons. In a word, the principles which Art *involves*, Science alone *evolves*."*

Although Natural Philosophy has other and higher aims than to augment the physical comforts of life, it should, at the same time, be remembered that it is constantly carrying on extensive, accurate, and successful enquiries into those very properties of matter, and laws of nature, which the practical man requires to know, in order that he may operate with full advantage. The Philosopher, impelled by his own peculiar tastes, may be said to open up the country; and, although it is not his business to stop and turn to account the treasures disclosed, the practical man will find it his interest to follow in his track, so that he may profit by his labours. Let us refer to the instance already quoted. Galileo, by experiment and patient induction, arrives at certain laws of terrestrial motion. Newton adopts these, extends them to the heavens, and ultimately arrives at the theory of the moon's motion. Science can now tell us how she moves, and why she so moves. All this progress was made without any direct intention of aiding the navigator. And yet a practical use of the highest value is extracted from this knowledge. The moon's position at every second—relatively to certain stars and planets, and to the sun—can be calculated; these distances are given in the Nautical Almanac. A seaman, on the wide ocean, measures with his sextant the moon's distance from one of these bodies—his Almanac tells him the instant of Greenwich time that such a position takes place; and thus, though

* Whewell's "Philosophy of the Inductive Sciences."

the vessel be solitary on the ocean, these theoretical laws declare to him his longitude, and the exact spot he occupies on the globe. Such deductions have given a security and impulse to commerce, the effects of which, on the civilization of man, cannot be easily calculated. "The alternatives of life and death," says Sir John Herschel, "wealth and ruin, are daily staked with perfect confidence on these marvellous computations, which might almost seem to have been devised on purpose to show how closely the extremes of speculative refinement and practical utility can be brought to approximate."

Practical Science takes advantage of the laws of nature for its own operations; it lays hold of the forces actually existing in the material world, and turns them to work for us. In this view, all nature becomes a treasury of forces, which may be drawn upon by him who has studied these laws. The physical strength of man is extremely limited, —with it alone he would wage a very unequal warfare even against the lower animals. But his reason makes him the Superior. The Winds of heaven he forces to convey him and his works over the sea, so that he may be surrounded with the luxuries of every climate;—the Waters become his willing slaves in moving that machinery which prepares, for food, or clothing, or furniture, the products which he has extracted from the soil, or taken from animals more richly provided;—and, above all, is Heat his untiring servant, grudging not to execute the most delicate, or the most gigantic operation, "drawing out," as has been expressively said,* "without breaking, a thread as fine as gossamer, or lifting a ship of war like a bauble in the air,—embroidering muslin and forging anchors, cutting steel into ribbands, and impelling loaded vessels against the fury of the winds and waves." And even that Electricity, recently

* By Lord Jeffrey.

described to be,* "in its effects, magnificent and terrific, indicating an uncontrollable power limited by neither space nor time, acting without warning, arising nowhere, reaching everywhere, contemptuous alike of vacancy and solidity, the power that flies through solid bodies as light does through empty space, unchecked, unretarded—attaining him who vainly strives to shelter himself under that which is his protection from light and heat and the mechanical powers, —the emblem of the all-reaching power which man cannot evade though he could command the mountains to cover him :"—even this power is man now forcing into his service, and constraining to convey his messages, with more than the speed of light.

Now, if I have described practical science properly, it cannot be easily conceived how any one should deny its connection with Philosophy, who is at all acquainted with the nature of that real science which has been advancing in Europe during the last two centuries. Were our teaching but the barren verbiage of ancient days, we could understand why a practical man should feel disgust at its name; but when we consider the cautious, strict, and laborious examination of nature, which is the first stage of all sound investigation, and the intellectual labour and the combination of thought which have been applied to the higher work of reaching, by induction, the general laws, we cannot but feel that such science is the store-house in which the man of practice may obtain that knowledge which is to give him a control and ascendancy over the matter around him and its laws. We conceive, then, that a little reflection on the nature of that experimental research, which is the foundation of all sound physical science, and on the process of in-

* See "Proofs and Illustrations of the Attributes of God, from the facts and laws of the Physical Universe." By John Maculloch, M.D. Vol. II., p. 304.

duction by which general laws, applicable to all special cases, are arrived at, cannot fail to impress the mind with the importance of the relation which subsists between science and practice. Experiment is a refined and accurate examination of physical qualities, a searching and cross-examining of nature, in order that she may declare her own secrets; and—the methods by which facts are observed and compared being now so completely understood—its evidence approaches in strength to that of demonstration. Philosophy ascends to the laws which combine phenomena thus elicited, often complicated and extensive; and, if such laws *have* been discovered—laws which express general relations—such summaries of nature's procedure must surely furnish the most valuable secrets to those whose business is to apply them.* Many arts are but instances of such applications. Archimedes, Stevin of Bruges, and Galileo, determine the laws applicable to the mechanical powers, not with the direct purpose of serving the mechanist; and yet all combinations of machinery to raise or remove weights, or in any way to overcome gravity—to produce compression, penetration, or in any way to overcome cohesion—to produce time-keepers, or in any way to regulate or equalize force—every such combination must be tested by these statical and dynamical principles. So also in Hydrostatics—Archimedes discovers the laws of flotation; Torricelli, Pascal, and Boyle, determine other laws of fluid pressure; and, ever since, Engineers have found in these the principles for the construction and management of diving bells, syphons, pumps, and other varieties of hydraulic machinery and

* "In the course of this descent to particulars, we must of necessity encounter all those facts on which the arts and works that tend to the accommodation of human life depend, and acquire thereby the command of an unlimited practice, and a disposal of the powers of nature co-extensive with those powers themselves." Herschell.

architecture. But to give the details will be the business of the future session.

It would be well if those who declaim against the use of theory would bear in mind that it is not the object of Philosophy to investigate rules for special cases of practice. Science, like a great high-way, opens up a region ; applications may bear some resemblance to secondary lines branching off into sequestered districts. The great business of the Engineer ought to be to reach the main line ; for it is matter of regret to find men of originality and energy of mind despising the scientific road, and labouring to work out for themselves a path among the uncleared wilds of their own speculations, while a broad and patent way to the same destination lies ready at their side.

An Engineer, or one who is being educated to assist in those almost miraculous advances going on around us in mechanical operations, should, at any labour, before entering on the study of the practice of his profession, acquire the habits of a scientific mind,—should early attain enlarged and comprehensive views of the material world and its arrangements,—should, in a word, have the philosophical culture which would lead him to look upon the forces and powers he has to deal with in the light of a science. Such a training would not only place knowledge at his command for his own purposes, but would liberalize his mind by interesting its highest powers in the details of his business; and, by giving him ideas of order, and system, and law, prevent his groping in the dark amid a perplexity of detail.

III. We are naturally led, by these considerations, to state now the great and primary reason why the study of Natural Philosophy forms an essential portion of University education: And it is this. The study of Nature affords appropriate intellectual training—the contemplation of the laws of the Universe tending to improve and expand the

mind, by opening up a view of the order and harmony of the material Creation.

"The contemplation of the material Universe," says a philosophical writer, "brings before us a wonderful spectacle, in the simplicity, the comprehensiveness, the mutual adaptation of these laws, and in the vast variety of harmonious and beneficial effects produced by their mutual bearing and combined operation." A thorough course of such science would not form part of your College education were its benefits confined to the sphere of the Mechanical Arts. To the man of leisure the knowledge of any art may be useful and gratifying; but, interesting and beneficial as many of these arts unquestionably are, the teaching of them does not find its way into Academical courses; and the reason is that they are special—that they constitute as arts no great generalizations—in a word, they are not Philosophy. We do not recommend the study of Mathematics as a part of an intellectual education, solely because it enables us to survey an estate, or calculate annuities, or determine a ship's longitude; neither do we press the study of Natural Philosophy solely because the processes of the Civil Engineer and the Mechanist are based upon its laws. Such uses to the practical man are all-important, and *he* will find it his interest first to study science as the surest road to professional eminence; but the study is presented to a much wider class, because the mind is invigorated and expanded by deciphering the laws, and contemplating the magnificence and harmony, of the machinery of the visible Universe.

I have already stated that the more we reflect on the purposes and effects of a general College education, the more must we be convinced that the culture of the intellectual and moral being—the formation of tastes and of character—is immeasureably more important than the communicating special kinds of knowledge or of tact; and yet one meets very frequently with those who cannot, or will not, distinguish

between the education of the *man* and the rearing of the future man of business. The special methods of practical occupations are acquired, in the most direct and serviceable way, under the eyes and among the employments of professional men. College courses have a different object. Our great Scottish Reformer devised, as part of his liberal scheme of national education, that the people, " ere they were set to travail for the sake of the commonwealth in some studie, exercise, or handicraft," should be enabled to devote a certain time to " the arts of Philosophy." Soon enough will our youth be harnessed to the burden of worldly business—soon enough will you be initiated into the arts of worldly ambition. Our Colleges keep sacred the few years of opening manhood for the cultivation of your higher nature—for the acquiring the love of truth for its own sake —for the instillation of ennobling motives. We are too well aware that there is a secular spirit abroad which would depreciate and contemn whatever is not *practical*, by which is meant, I suppose, whatever is not obviously available in the details of a business-life, or in the art of money-making,—would encourage science only so far as its results are of immediate application,—and would thus sacrifice on the shrine of a mistaken self-interest, all that is elevating in Philosophy, all that is generous in our nature, and all within us that points to immortality.

I previously adverted to that class of intellectual advantages which arises from accustoming the mind to the strict and beautiful reasoning which this science employs. But, when great laws are by its means obtained, the mind is further elevated and strengthened by the spectacle of vastness, and yet of consistency, which is laid open. The human mind has been occupied in the pursuit of truth—its own element—for many ages, and has penetrated, to some extent, into the secrets of Nature's operations—has explained the causes of some of those beautiful arrangements for ad-

ministering to the comfort of living beings, by which we are surrounded; and you may now have access to these ennobling views without the labour of discovery. *They are your inheritance by birthright, if you will but enter into possession.* The contemplation of these harmonious adaptations constitutes the highest intellectual pleasure, and is an employment which links us with superior intelligences—raising the mind above the gratification of the senses, and the trifling pursuits of the worldling. "Nam corpus hoc animi pondus et pœna est; premente illo urgetur, in vinculis est, nisi accessit Philosophia, et illum respirare rerum naturæ spectaculo jussit. Vetas me cœlo interesse, id est, jubes me vivere capite demisso."*

IV. Lastly, we will consider it our duty to lead the thoughts of the student of Nature, as occasion offers, to the Great First Cause.

It is important to remark, that when we have exercised the intellect, we have fulfilled but a portion of our duty—that there is still a higher kind of existence than the intellectual—that, while we are required to cultivate the powers of mind bestowed on us by our Maker, which can be so well done in the field of Nature spread out before us, we must rise still higher—and that the contemplation of all the order and harmony of the Universe should lead the thoughts up to the Supreme mind, which planned and governs the great system. It appears to us to be unphilosophical not to refer all the adaptations and arrangements we discover to a Designer. It is the natural untaught process of the mind, when we discern contrivance, to refer it to a contriver; and—if, when we see skill and adaptation in human works, judging from our own consciousness, we refer such to *other* designing minds—we are not to be stopped when we

* Seneca.

deal with adaptations beyond our limited powers to produce, but should allow our thoughts to rise, from the works of Nature, to the Almighty Architect and Governor of Nature.

Such views, constantly accompanying our surveys of Creation, invest our enquiries with a tenfold greater interest, and spread a bright and cheering light on every portion of our path. Natural Philosophy thus studied is no longer a dry detail of material operations, or an enquiry into the action of what some have called "necessary and eternal laws," but a continual tracing out and deciphering the handiwork of a beneficent Parent. Such a procedure is best for Philosophy, best for our moral growth and well-being, and best fitted to harmonize with the habits of those who adopt that pious sentiment—"bene orasse est bene studuisse."

It is the observation of the adaptation of means to ends that impresses us with the idea of a wise and presiding Divinity. The whole range of the science of nature abounds with illustrations. In the case of the inductive and more exact sciences of Astronomy and Mechanical Philosophy, the effect produced on the mind differs, in some respects, from the impression derived from particular instances—these sciences dealing with laws and great generalizations. But we believe that every kind of natural science can be so studied as very much to deepen the impression of an omniscient and omnipresent God. "The contemplation of God in his works," says a formerly quoted writer, "is calculated to excite the spirit of *habitual* admiration and praise, and to produce a steady conviction of his superintending presence, and of his love and care for all that He has created." We freely admit—what all true philosophy, all history, confirms—that science is in itself altogether insufficient to furnish the light which we require on the character of God, or on the path of moral duty; but it may have a very valuable use in helping us to the conception of many of the Divine perfections.

"Hæc cum meditaris studiose," says Luther, "invenies Deum."

There is a notion somewhat prevalent, that Natural Philosophy leads to scepticism, by referring all material operations to the agency of *laws of nature,* by teaching that the world is *governed* by such laws, and thus leaving us to conclude that the superintending Providence of the Deity is not required. We know that the subject may be so represented as to make *gods* of these laws of nature. But such procedure takes its rise from a total misconception of the philosophical meaning of the terms employed. *A law of nature* is the uniform course of action which the Deity has chosen to follow. "A law," as has been well expressed by an eminent living philosopher, "supposes an agent and a power; for it is the mode according to which the agent proceeds, the order according to which the power acts. Without the presence of such an agent, of such a power, conscious of the relations on which the law depends—producing the effects which the law prescribes—the law can have no efficacy, no existence. The laws of nature are the rules which the Divine Being prescribes to his own acts; his universal presence is the necessary condition of any course of events; his universal agency the only origin of any efficient force." Let us observe what consequences follow from the assumption that laws of nature produce physical changes. We shall instance the law of gravitation, or Newton's laws of motion. Let it be granted that the truth of these is established. Now, in order that we may declare what dynamical effect will be produced on a given body, in certain known circumstances, in conformity with these laws, it is necessary for us to go through a process of geometrical or analytical deduction, involving subtle combinations, and, in many cases, intricate calculations; and thus we would deduce what the body should do if it obey

these laws. And this it is found to do, exactly as the deduction prescribes. Are we now to conclude that a mass of inert matter, at the bidding of what is called a law, could apply Geometry and calculation to regulate its own motions? are we to say that it could shape its course by processes too abstruse to be understood by any but skilful mathematicians? or are we not rather to say that the body was directed in its motions by the finger of that God who chose, for wise and benevolent purposes, to prescribe for himself such a course of uniform procedure?

If we cultivate proper habits of thought, the study of nature will afford many advantages in enabling us to form lofty conceptions of God. These studies may undoubtedly be made the means of greatly *extending* our views of the Divine agency; and, by leading us to discover the Providence of God, where we had never before conjectured its presence, may enable us to feel the universal range of his creating and preserving power. For example: by reflecting on the countless numbers of living beings which people all the districts of our own world—the forest, the field, the air, the sea, the desert—by contemplating all these regions as teeming with life, with distinct organizations suited to their circumstances, and to all the varieties of climate—the elements constantly ministering to their several wants—we approach to a lofty conception of the greatness of that Being who superintends this varied Empire. But science widens the view almost infinitely. A similar system is, in all probability, repeated in every planet. The telescope, however, multiplies the stars of heaven beyond all conception, leading us to conclude each shining point to be the centre of a system like our own. We are entitled to conceive a similar system—from the lowest animalcule upwards to the sun—in every such twinkling point in the sky. Such is the empire of the Almighty, such the varied interest he upholds, such

the wide sphere which he is continually filling with His proofs of his goodness.*

And, if the revelations of the telescope should impress *us* with a fear of being overlooked amidst the multiplicity and greatness of the Almighty's concerns, let us turn to the discoveries of the microscope. "The one," says Chalmers, "taught me that this mighty globe, with the whole burden of its people and its countries, is but a grain of sand on the high field of immensity. The other teaches me, that every grain of sand may harbour within it the tribes and the families of a busy population.—By the one I am told that the Almighty is now at work in regions more distant than Geometry has ever measured, and among worlds more manifold than numbers have ever reached. But, by the other, I am also told, that, with a mind to comprehend the whole, in the vast compass of its generality, He has also a mind to concentrate a close and a separate attention on each and on all its particulars; and that the same God, who sends forth an upholding influence among the orbs and the movements of astronomy, can fill the recesses of every single atom with the intimacy of his presence, and travel in all the greatness of his unimpaired attributes, upon every one spot and corner of the universe he has formed."†

I shall give you one other illustration, in the striking language of Macculloch ‡:—"The atmosphere exists but through the power of *Heat*. But for the presence and energy of heat, this great and indispensible portion of the globe would be a solid body, perhaps an equally unknown and useless form of matter. It is through heat that the water of the earth is dissolved in the atmosphere, as a store for future rains; acquiring that levity under which it can

* See Whewell's Bridgewater Treatise. Book III. Chap. 2.

† Chalmers' Astronomical Discourses. Discourse 3rd.

‡ "Proofs and Illustrations of the Attributes of God." Vol. II. page 332.

be transported with the velocity of wind around the globe. Had the problem been put to man in a state of ignorance, were it even now said to him who did not chance to know or recollect it, that water—and not only water, but the heaviest metals—could be raised from the earth, despising or renouncing that force of gravity which seems inseparable from their very existence, that neither bulk nor weight was an obstacle to their ascent, that the whole ocean might quit the earth and float in empty space, he would not believe in the possibility. Less still would he be inclined to believe it, were he told that this was the work of a silent and invisible agent, an unseen existence ever about him, a gigantic spirit occupying all surrounding space, dwelling in every thing, dwelling in himself, unheard, unfelt, unseen. Yet it is even thus; the very language in which it is here expressed is not that of poetry, but truth. Would he, to whom this was for the first time stated, believe that this invisible spirit possessed that magical power which romance attributes to its enchanters, rendering invisible, like itself, whatever it touched, and thus transporting it through the regions of air? that, like the Arab Genii, it could fly with the palaces of the world in its hand across the mountains of Caucasus, hidden from all eyes? He would deny the possibility of that which is before him daily and hourly.—Almighty power has solved this problem; and in these very terms has He solved it; solved it, too, with so much ease, and so simply, that we fail to note, and forget to admire. The great spirit of Heat is the magician; *but it is the Enchanter in His own hands.*"

We must now draw our remarks to a conclusion. If, by the exercise of those faculties with which we have been endowed, directed to the Book of Nature spread out before us—a process itself furnishing proof of the adaptation of the intellectual to the material order of things—if, by our attempts to read its language, we are aided in forming lofty

conceptions of the Ruler of the Universe, surely such contemplations should not be overlooked by those who desire to learn more of the power and excellence of the Maker of all things. And it is a happy sign of our times, that every man whom we are entitled to honour as a Master in science, in our country, exhibits in his writings that he is friendly to the great truths of religion. These names we need not enumerate. We might quote from a large number of those writers who have exemplified the spirit of Bacon's philosophy, or have aided in its triumphs, during the last two centuries—from Kepler, and Galileo, and Torricelli, and Pascal, and Newton, and Boyle, down to Dalton—to show that such studies are friendly to the belief in a wise and benevolent Governor. It is true, as Bacon has told us, that a superficial survey of the world of knowledge may be productive of a vertiginous and intoxicating effect favourable to human vanity; but men of this temper are disclaimed by those who have imbibed the spirit of the inductive philosophy. Instead, however, of quoting from these authorities, high as they are, let us look to the inspired penmen. Here is the exercise of a pious mind drawing nutriment from the observation of the works of God:—"*Oh Lord, how manifold are thy works! in wisdom thou hast made them all—Thou visitest the earth and waterest it: thou greatly enrichest it with the river of God, which is full of water: thou preparest them corn, when thou hast so provided for it. Thou waterest the ridges thereof abundantly; thou makest it soft with showers; thou blessest the springing thereof; thou crownest the year with thy goodness. The eyes of all wait upon thee; and thou givest them their meat in due season. Thou openest thy hand, and satisfiest the desire of every living thing.*"*

We shall conclude with a quotation from another hymn.†

* See Psalms 104, 65, 145. † Psalm 19.

"*The Heavens declare the glory of God; and the firmament sheweth* HIS *handiwork. Day unto day uttereth speech, and night unto night sheweth knowledge.*" Such sentences contain our whole argument. It was an argument which produced its impression in an age when little comparatively was understood of the real beauty of this handiwork; far more, therefore, ought it to be an argument to us who have learned more of the meaning of these words. And, as the best sequel to our illustrations, let us follow the train of thought which the inspired writer indulges. After extolling the power, and wisdom, and providence of God, as shewn in external nature, he passes to a higher subject:—"*The* LAW *of the Lord is perfect, converting the soul: the testimony of the Lord is sure, making wise the simple: the statutes of the Lord are right, rejoicing the heart: the commandment of the Lord is pure, enlightening the eyes: the fear of the Lord is clean, enduring for ever: the judgments of the Lord are true and righteous altogether. More to be desired are they than gold, yea, than much fine gold; sweeter also than honey, and the honeycomb.*"

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